Pakistan Veterinary Journal

ISSN: 0253-8318 (PRINT), 2074-7764 (ONLINE)
Accessible at: www.pvj.com.pk

RESEARCH ARTICLE

Effect of Captive Environment on Plasma Cortisol Level and Behavioral Pattern of Bengal Tigers *(Panthera tigris tigris)*

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ARTICLE HISTORY

Received: December 15, 2010
Revised: January 15, 2011
Accepted: January 16, 2011

Key words:
Captivity
Cortisol
Environmental enrichment
Stereotypic behavior
Stress

ABSTRACT

Captive environment in zoological parks often does not provide optimum conditions for natural behaviors due to spatial constraints and negative public reaction. These factors elicit stereotypic behavior in tigers such as pacing, head bobbing and aimless repetition of some movements, and are considered to be an indication of stress. The present study was conducted to assess the effect of captivity on the plasma cortisol level and behavioral pattern in Bengal tigers (*Panthera tigris tigris*). Tigers kept in captivity at the Lahore zoo (n=4) and in semi natural environment at the Lahore Wildlife Park (n=6) were used for this study, and standard protocols of housing and sampling were observed. The mean plasma cortisol values for the captive animals and those kept in a semi natural environment were 34.48±1.33 and 39.22±3.16 µg/dl, respectively. The difference was statistically non significant. Similarly, no significant difference in the plasma cortisol levels was observed among the individuals within each form of captivity. From the behavioral survey it was observed that the time spent in pacing and resting was much longer for captive animals than animals confined to the semi natural environment. Thus, technically monitored "Environmental Enrichment' plans need to be devised which are as close as possible to the natural environment of the captive animals in order to achieve their utmost performance.

To Cite This Article: Sajjad S, U Farooq, M Anwar, A Khurshid and SA Bukhari, 2011. Effect of captive environment on plasma cortisol level and behavioral pattern of Bengal tigers *(Panthera tigris tigris)*. Pak Vet J, 31(3): 195-198.

INTRODUCTION

With a rapid loss of species worldwide, long term maintenance of the captive population has become a common approach to species conservation. Apart from serving the main aim of conservation, these captivity modules such as zoos, sanctuaries and wildlife parks serve as a seat of education, research and recreation as well (Mench and Kreger, 1996; McPhee, 2003). However, abnormal behaviors may develop in animals where the captive, human-made environment is not suitable for them to carry out their natural or instinctive behaviors (Carlstead, 1996). These sets of abnormal, unnatural behaviors are referred to as 'stereotypies', described as unvarying, repetitive behavioral patterns with no apparent goal or function (Fox, 1965). Stereotypies are associated with environmental conditions that stimulate arousal, conflict or frustration in the animal exhibiting the behavior (Dantzer and Mittleman, 1993). Boredom may also elicit a stereotypic response under certain situations (Wemelsfelder, 1993). The coping hypothesis suggests that stereotypic behavior results as a response to a stressful situation and is used as a means of managing the situation (Cooper and Nicol, 1991) and hence is considered to be an indication of stress.

In mammals, challenges to homeostasis commonly evoke a series of endocrine and neural actions known as the stress response. While not as stereotyped as once thought, the stress response typically involves the release of catecholamines from the sympathetic nervous system and adrenal medulla, release of adrenocortical glucocorticoids (primarily cortisol), and the initiation of a variety of other endocrine responses, including suppression of hormones related to anabolism, growth, and reproduction (Sapolsky, 2002). Collectively, the stress response aids in adapting an individual to an acute stressor by stimulating hepatic glucose release and visceral lipolysis, enhancing the delivery of glucose, fatty acids,

and triglycerides to the skeletal muscle and brain, triaging processes nonessential to immediate survival, and constraining inflammatory and immune responses. Despite these adaptive functions, it has long been recognized that chronic or prolonged activation of the stress response can have deleterious physiological and behavioral effects (Abbott *et al*., 2003). Behaviorally, chronic stress may be indicated by reduced reproductive behavior (Gronli *et al*., 2005), exploratory (Vyas and Chattaji, 2004), behavioral complexity (Rutherford *et al*., 2004) and latency to freeze (Korte, 2001). Similarly, increased abnormal behavior (Carlstead and Brown, 2005), behavioral inhibition (Vyas and Chattaji, 2004), vigilance behavior and hiding, aggression (Morgan and Tromborg, 2007), fearfulness and frequency of startle (Boissy *et al*., 2001) and freezing behavior (Korte, 2001) have been reported due to chronic stress.

There is a dearth of published literature regarding the stereotypic behavior of tigers kept in captivity in Pakistan. This study was hence conducted to assess the effect of captivity on the plasma cortisol level and behavioral pattern of tigers kept in the Lahore zoo and the Lahore Wildlife Park (LWP), Pakistan.

MATERIALS AND METHODS

Study site and experimental animals

The present study was conducted on the tigers of Bengal origin *(Panthera tigris tigris)* kept at the Lahore zoo, Mall Road, Lahore and the LWP located on the Raiwind Road, 32 km from the main city of Lahore, in the year 2007-08. The tigers from the Lahore zoo (n=4) lived solitary, consisting of two males and two females; whereas the tigers from the LWP (n=6) lived in social groups consisting of five males and one female. All of the animals ranged from 1 to 4 years in age and from 140 to 170 kg in body weight.

Housing and feeding

The Bengal tigers housed in captivity at the Lahore zoo were kept in indoor enclosures (approx 25×10×15 ft) with wired fence on the front and back for the provision of natural light. The floor was tiled and there were solid opaque walls on the sides which prevented physical and visual contact with animals housed in adjacent cages. All cages were provided with fans, air coolers and a water pool with water *ad libitum.*

The Bengal tigers in the semi natural environment of LWP were kept in outdoor enclosures with ample space (15 acres). This environment was provided with dense vegetation consisting of trees, bushes and grass. Man-made hills and hideouts were also provided as a natural housing for the tigers.

Tigers were fed a 24 hour standard diet consisting of 1 liter of milk and 7-8 kg of meat. None of the tigers were ill or involved in any other study/trial that might influence this study.

Standard capture and sampling protocols

Standard capture protocol was used and observed at both sites of the study i.e. the Lahore zoo and the LWP. This involved herding the animals to a corner of their enclosure with the help of hand operating doors and directional iron rods, and finally capturing the animals in squeeze cages (8×7×8 ft). After this, the animals were screwed in squeeze cages with the help of a lever and allowed to settle down in order to normalize their body temperature and heart beat.

After squeezing in, 5ml of blood was collected aseptically in heparinized syringes from the common tail vein (dorsal coccygeal vein) of restrained un-anaesthetized animals. In order to minimize the stress to the animal and to standardize the collection procedure, all animals were restrained with the same technique, the collection was made by the same personnel and at the same time of the day i.e., between 9 am to 12 am. Blood samples were transported in an ice box to the Department of Zoology, Lahore College of Women University, Lahore for analysis.

Assessment of plasma cortisol levels

Plasma was extracted by centrifugation at 2000 rpm for 15 minutes and analyzed for cortisol level through Active Cortisol ELISA Kit (Accu-MonoBind, MonoBind Inc., 100 North Pointe Drive, Lake Forest, CA 92630 USA).

Behavioral survey

Behavioral survey was done through a 'focal animal' sampling method using an ethogram which was devised earlier during a preliminary observation made on tiger behaviors in June 2007 at the Lahore zoo (Table 1). Behavior of individual animals was recorded every 10 minutes from 12:30 to 01:30 pm daily for a period of two months (Lyons *et al*., 1997; Shepherdson *et al*., 1993). At 10-minute intervals, the related behaviors were consolidated into two groups, i.e. stereotyping (pacing) and resting.

Table 1: Ethogram of tiger behavior used in the present study

Stereotypies	Rest	Others
PC- Pacing	LB- Laying Back	OE- Off Exhibit
	RA- Resting Awake	CS- Cannot See
	SI- Sitting	
	SL- Sleeping	

Created from the work of Baldwin (1991) and Lyons *et al.* (1997)

Statistical analysis

Data for plasma cortisol level is expressed as mean and standard error of mean (±SEM). Following homogeneity of variance, comparisons among and between animals kept in captivity at Lahore zoo and the LWP were made using t-test through Microsoft Office Excel 2000.

RESULTS AND DISCUSSION

Plasma cortisol levels

The comparative mean (±SEM) values of plasma cortisol levels of tigers confined to captivity at Lahore zoo and LWP are presented in Table 2. Mean plasma cortisol levels of 34.48±1.33 and 39.22±3.16 µg/dl were recorded for tigers kept in the Lahore zoo and the LWP, respectively. Although the variation of range was clearly observed within both groups, no statistically significant difference was found in the plasma cortisol level among

individuals within both the populations of captive animals. The cortisol concentrations recorded in the present study are higher than those reported by other workers elsewhere. Byers *et al.* (1990) have reported mean cortisol levels of 11.6±3.8 µg/dl in captive male Siberian tigers (*Panthera tigris*), whereas Nogueira and Silva (1997) have reported a 6.01±1.19 µg/dl plasma cortisol concentration in captive jaguars (*Panthera onca*). A plausible explanation of higher values in the present study is the effect of season or breed.

Though the environments of the study animals for both populations varied greatly, statistically non significant difference was observed in the mean plasma cortisol levels of both populations, with the values being slightly higher for animals kept at the LWP. These results are in line with the findings of Kleiman *et al*. (1990) and Britt *et al*. (1999), who reported that individuals/animals of an established captive population attain certain 'behavioral deficiencies' and 'physiological adaptations' in order to survive in the captive environment. Similarly, Brown *et al*. (1988) reported lower overall cortisol concentrations during subsequent bleeding periods, indicating a rapid 'adrenal adaptation'. The animals kept in the Lahore zoo in the present study were adapted to the captive environment by birth and hence had shown no elevated cortisol levels. Such physical adaptations make it possible for the animal to live in a particular place and in a particular way; and have evolved after many generations. Similarly, the animals kept in the semi natural environment of the LWP were physiologically adapted to that particular environment; however, their mean plasma cortisol level was slightly higher than that of the zoo captive animals. This slight elevation may be due to the stress of squeeze caging while sampling.

Table 2: Comparative mean (± SEM) values of plasma cortisol levels of tigers confined to captivity at Lahore zoo and Lahore Wildlife Park (LWP)

Captivity form	No. of animals	Plasma cortisol (µg/dl)	Range (µg/dl)
Lahore Zoo	04	34.48±1.33	17.88-54.52
LWP	06	39.22±3.16	25.21-57.78

Behavioral analysis

The comparison of the mean percentages of pacing and resting recorded in a one-hour period, shown by animals kept in Lahore zoo and in the LWP is presented in Table 3. The results revealed that the animals kept in Lahore zoo spent most of their time resting (10.54% of the observed hour) in a single location of their enclosures as compared to the animals kept in the LWP. These results are in accordance with the findings of Baldwin (1991), who reported that cats in the National Zoo, USA rested 75% of the time and used only 1/3 of their available space. Lyons *et al*. (1997) also found that nine species of captive felids used little of their enclosure spaces at the Scottish National Zoological Park. Similarly, the time spent in (stereotyping) pacing for the animals kept at the LWP was 1.47% as compared to 10.68% for zoo captive animals. These results are in line with those of Lyons *et al*. (1997), who reported that the behavioral pattern of 19 captive felid species in larger enclosures was less stereotypic. Similarly, Mellen *et al*. (1998) found that the relationship between pacing and several variables that characterize the physical and social environment was a useful measure of well being in captive animals. In most of the cases, the smaller the enclosure, the more likely a captive animal will display stereotypies (Carlstead, 1996).

Table 3: Comparison of mean percentages of pacing and resting recorded in an hour, shown by animals kept in zoo and in the LWP

Captivity form	No. of animals	Parameters	
		Pacing	Resting
Lahore Zoo	04	10.68	10.54
LWP	06	1.47	2.40

Conclusions

The present study clearly indicates that environment, whether captive or semi natural, has no effect on plasma cortisol levels, but it has ample impact upon the behavioral pattern of the animals. Environmental enrichment is strongly recommended for the maintenance of the physical and psychological behavior of captive animals.

Acknowledgements

This work was completed in partial fulfillment of the requirements for the degree of Master in Science (MSc) in Zoology at Lahore College for Women University, Lahore, Pakistan. We are grateful to Mr. Asif, Director of Wildlife; Mr Yusaf Pall, Director of Lahore zoo and Mr. Shafqat, Director of Lahore Wildlife Park for granting the permission to conduct this research. In addition, we thank the whole staff of Lahore zoo and Lahore Wildlife Park for the provision of positive feedback, skillful guidance and smooth implementation of the research design.

REFERENCES

Abbott DH, EB Keverne, FB Bercovitch, CA Shively, SP Mendoza, W Saltzman, CT Snowdon, TE Zeigler, M Banjevic, T Garland and RM Sapolsky, 2003. Are subordinates always stressed? A comparative analysis of rank differences in cortisol levels among primates. Horm Behav, 43: 67-82.

Baldwin RF, 1991. Behavior of carnivores in outdoor exhibits at the National Zoo. Master's Thesis, George Mason University, Virginia, USA.

Boissy A, I Veissier and S Roussel, 2001. Behavioural reactivity affected by chronic stress: an experimental approach in calves submitted to environmental instability. Anim Welfare, 10(Suppl): S175–S185.

Britt A, A Katz and C Welch, 1999. Project Betampona: conservation and re-stocking of black and white ruffed lemurs (*Varecia variegate variegata*). Proc. 7th World Conference on Breeding Endangered Species: Linking Zoo and Field Research to Advance Conservation, Cincinnati, USA, March 10-13, 1999, pp: 37-38.

Brown JL, KL Goodrowe, LG Simmons, DL Armstrong and DE Wildt, 1988. Evaluation of the pituitary-gonadal response to GnRH, and adrenal status, in the leopard (*Panthera pardus japonensis*) and tiger (*Panthera tigris*). J Reprod Fert, 82: 227-236.

Byers AP, AG Hunter, US Seal, EF Graham and RL Tilson, 1990. Effect of season on seminal traits and serum hormone concentrations in captive male Siberian tigers. J Reprod Fert, 90: 119-125.

Carlstead K, 1996. Effect of captivity on the behavior of wild mammals. In: Wild Mammals in Captivity: Principles and Techniques (Kleiman D, Allen ME, Thompson KV, Lumpkin S, eds.); University of Chicago Press, Chicago, USA, pp: 317-333.

Carlstead KE and JL Brown, 2005. Relationships between patterns of fecal corticoid excretion and behavior, reproduction, and environmental factors in captive black (*Diceros bicornis*) and white (*Ceratotherium simum*) rhinoceros. Zoo Biol, 24: 215–232.

Cooper JJ and CJ Nicol, 1991. Stereotypic behaviour affects environmental preference in bank voles, *Clethrionomys glareolus*. Anim Behav, 41: 971–977.

Dantzer R and G Mittleman, 1993. Forms of stereotypic behavior. In: Stereotypic Animal Behavior: Fundamentals and Applications to Welfare (Lawrence AB, Rushen, J eds.), CAB International, Wallingford, Oxon, UK, pp: 148–172.

Fox MW, 1965. Environmental factors influencing stereotyped and allelomimetic behaviour in animals. Lab Anim Care, 15: 363–371.

Gronli J, R Murison, E Fiske, B Bjorvatn, E Sorensen, CM Portas and R Ursin, 2005. Effects of chronic mild stress on sexual behavior, locomotor activity and consumption of sucrose and saccharine solutions. Physiol Behav, 84: 571–577.

Kleiman D, B Beck, A Baker, J Ballou, L Dietz and J Dietz, 1990. The conservation program for the golden lion tamarin, *Leontopithecus rosalia*. Endangered Species Up-Date, 8: 82–85.

Korte SM, 2001. Corticosteroids in relation to fear, anxiety, and psychopathology. Neurosci Biobehav Rev, 25: 117–142.

Lyons J, R Young and J Deag, 1997. The effects of physical characteristics of the environment and feeding regime on the behavior of captive felids. Zoo Biol, 16: 71-83.

McPhee ME, 2003. Generations in captivity increases behavioral variance: Considerations for captive breeding and reintroduction programs. Biol Conserv, 115: 71-77.

Mellen JD, M Hayes and D Sheperdson, 1998. Captive environments for small felids. In: Second Nature: Environmental Enrichment for Captive Animals. Smithsonian Publishers, Washington DC, USA, pp: 184-201.

Mench JA and MD Kreger, 1996. Ethical and welfare issues associated with keeping wild mammals in captivity. In: Wild Mammals in Captivity: Principles and Techniques (Kleiman D, Allen ME, Thompson KV, Lumpkin S, eds.): University of Chicago Press, Chicago, USA, pp: 5-15.

Morgan KN and CT Tromborg, 2007. Sources of stress in captivity. Appl Anim Behav Sci, 102: 262-302.

Nogueira GP and JCR Silva, 1997. Plasma cortisol levels in captive wild felines after chemical restraint. Braz J Med Biol Res, 30: 1359-1361.

Rutherford KMD, MJ Haskell, C Glasbey, RB Jones and AB Lawrence, 2004. Fractal analysis of animal behaviour as an indicator of animal welfare. Anim Welfare, 13(Suppl): S99–S103.

Sapolsky RM, 2002. Endocrinology of the stress-response. In: Behavioral Endocrinology (Becker J, Breedlove S, Crews D, McCarthy M, eds.): MIT Press, Cambridge, UK, pp: 409–450.

Shepherdson D, K Carlstead, J Mellen and J Seidensticker, 1993. The influence of food presentation on the behavior of small cats in confined environments. Zoo Biol, 12: 203-216.

Vyas A and S Chattaji, 2004. Modulation of different states of anxiety-like behavior by chronic stress. Behav Neurosci, 118: 1450–1454.

Wemelsfelder F, 1993. In: Stereotypic Animal Behavior: Fundamentals and Applications to Welfare (Lawrence AB, Rushen J eds.): CAB International, Wallingford, Oxon, UK, pp: 66–95.